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RESEARCH ARTICLE

BIBLIOMETRIC STUDY OF PAKISTAN'S RESEARCH OUTPUT AND COMPARISON WITH OTHER SELECTED COUNTRIES OF THE WORLD

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ABSTRACT

This study attempts to analyze the growth and development of publication output in Pakistan during the period 1996-2010.The scientific output of Pakistan has been evaluated by focusing on its publication growth characteristics, research impact and quality, patterns of research collaboration and broad research fields.This bibliometric study also compared the productivity, growth and impact of research output of Pakistan with other 14 selected countries by using many types of bibliometric indicators. Of the world's total scientific papers of 23313389, Pakistan contributed 38274 papers or 0.16% and ranked 48 among 236 countries of the world. It has been found that publications of Pakistan grew to 682.42% in 2010 as compared to 1996. Pakistan's relative share in the scientific output in the world has increased from 0.08% in 1996 to 0.32% in 2010 . Pakistan stands fifteenth in research output, thirteenth in average citation per paper, fifteenth in h-index within the group of countries selected for comparison. 30.84% of Pakistan's total papers involved international collaboration. Comparing the ratio of scientific output to GDP, Pakistan stands fourteenth place among 15 selected countries and in terms of the number of publications in relation to the size of the population, Pakistan ranked at the bottom with 207 publications per one million Population . In terms of GERD/GDP ratio Pakistan stood at fourteenth position.

Key words: Publication output, Bibliometric indicators, Citation impact, Relative growth

INTRODUCTION

Science and technology development have become critical instruments in the public policy arena given their demonstrated impact on economic progress. The global landscape of science and technology is undergoing radical changes. A rapid progress has been made in all branches of science and technology over the past two decades. Science and Technology research are viewed an indispensible part of countries economic (Hyung, 1988; Mansfield, 1991) and social (Hyung, 1988; Sitthi-Amorn and Somronthong, 2000) development. R&D expenditure plays a major role in shaping the scientific research landscape. Developed countries spend some 2 to 3% of their GNP on R and D (Sharif, 1986). The budg *et al* location to research in the third world countries is a very scant share of GNP. Developed countries' share of world scientific publications has declined over the last 20 years. According to Alabi (1989) there has been tremendous growth in scientific activities in most of the third world countries Saracevic (1977) also expressed similar sentiments when he said that the rate of the scientific activities have been tripling in most developing countries compared with the doubling tempo in the developed countries. The evaluation of scientific output in developing countries is difficult due to problems such as the lack of appropriate scientific indicators, scarcity of available data and annual changes in economic growth parameters. In recent years policy makers and research managers have become increasingly interested in the use of indicators of scientific output. Bibliometry, the measurement of scientific publications and their impact on the scientific community, assessed by the citations they attract, provides portfolio of indicators that can be combined to give a useful picture of recent research activity. The indicators enable an output-oriented "system analysis" of research capabilities, activity and related scientific interactions. These bibliometric indicators, acting as impartial 'observers' of science, provide objective data on several key features of research capabilities, collaboration, outputs and impacts. Garfield carried out the first major analysis of the world research output, with particular reference to third world science publications in 1973, using SCI database and their citations received from 1973 to 1978. Currently, there are a number of ways in which output can be measured including simple paper counts, citations, impact factor analysis (Avital and Collopy, 2001) and more recently h-index analysis (Hirsch, 2005). A bibliometric indicator is a measure or a statistic to the impact or quantity of publications as documentary products. Ley desdroff considers a bibliometric indicator as anything that might count about text. Bibliometric indicators have been widely used in national science and technology statistics publications to measure scientific capacity linkage to world science, both in developed and developing countries. Bibliometric indicators seek to measure the quantity and impact of scientific publications-as a proxy for overall output of scientific research and are based on a count of scientific papers and the citation they receive. Van Raan (2003. 2006a, 2006b) proposed and used standard bibliometric indicators in research assessment and both intra-disciplinary and interdisciplinary research performances. Some of the indicators used were the number of papers published (P), the total number of citation (CPP), percentage of not-cited papers (%Pnc) and h-index.

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Number of articles (P)

The first indicator is the total number of papers published during the time period considered (P). Paper counts, which measure productivity, are the most basic bibliometric measure. The volume of research papers published by a country is used as an indicator of the volume of research taking place.

Number of Citations (C)

The second indicator is the total number of citations received by the papers during the time period considered, without self-citations (C). Citations measure impact and influence. Citations to papers are summed over some time period to create an aggregate citation count. Citation counts (the number of citations) are used in research evaluation as an indicator of the impact of the research: The impact of a piece of research is the degree to which it has been useful to other researchers' (Shadbolt *et al*. 2006, p.202; see also Bornmann& Daniel 2007a). Following Van Raan 2004, citation-based bibliomtric analysis provides indicators of international impact, influence.

Citation per articles (CPP)

The third indicator is the average number of citations per publication, corrected for self- citations (CPP). CPP is a useful indicator of publication quality. Citation per publication CPP), defined in Kronman and Wadskog (2007), is usually used as a measure of quality of scientific production of countries. Using CPP instead of absolute citation number eliminates the effect of publication number in quality comparisons. The relative number of citations is also often considered a proxy measure of visibility in the scientific community. Citation per paper sometimes called impact is computed by dividing the sum of citations to some set of papers for a defined time period by the number of papers.

Percentage of uncited articles (%Pnc)

The fourth indicator the percentage of articles not- cited during the time period considered, self-citations are excluded (%Pnc). %Pnc concerns, like all other indicators, the given time period. It is possible that publications not cited within such a time period will be cited after a longer time. The proportion of un-cited papers in a dataset can be compared to a benchmark. As many as 35% of world research publications may remain un-cited in a typical ten-year sample, even for leading research economies.

H-index

The h- index is a distribution- based indicator that corresponds to the number of papers at or above a given citation level equal to the value of the threshold. The measure attempts to reflect both productivity (number of papers) and impact (number of citations) in one number. The h index is a country's number of articles (h) that have received at least h citations. It quantifies both country scientific productivity and scientific impact. The h-index is intended to measure simultaneously the quality and sustainability of scientific output, as well as, to some extent, the diversity of scientific research. The h-index attempts to provide an indication of both quantity and impact, and it has been argued that h-index provides a better predictive indicator of scientific achievement than other biometric markers, including total citation count or citation per count (Hirsch, 2007).

Relative Citation Impact

The relative citation impact provides a rough indication of the visibility and scientific impact of research. The number of times papers of the country are cited can be compared with the number of times all papers in the database are cited. A relative citation impact can thus be calculated by dividing the citations per paper for a country by the average number of citations per paper for all papers (the world output)

Number of Publications relative to Population

Publication per population (PPP), as defined in Kronman and Wadskog (2007), is commonly used as a measure of the quantity of scientific production of countries instead of the absolute publication number. It removes the effect of population number when comparing differently populated countries.

Number of Publications relative to GDP

GNP is the most important determinant of the total number of high-quality papers produced by a nation's scientists. Price studied the determinants of national scientific productivity and suggested that a country's share of the world's scientific literature is almost completely determined by its gross national product (GNP), i.e., large wealthy countries produce the bulk of the world's science. A report published in Science, Robert May has shown there are great inequalities in the amount of science produced by various nations. Currently, the United States alone produces more than one third of the world's science, and the overwhelming majority is produced by a relatively small number of wealthy countries.

R&D Expenditure Relative to GDP

Expenditure on research and development (R&D) is a key indicator of government and private sector efforts to obtain competitive advantage in science and technology. Expenditure for research and development are current and capital expenditures on creative work undertaken systematically to increase knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.

International Collaboration

Collaboration is important for information flows within the R&D system. It promotes the creation of new knowledge with a broader base. The expanding network of research collaboration has been a predominant feature of the global research base. International collaboration can be an important indicator of the reach and impact of a country's research. Adams *et al*. (2007:3) states that international research activity is rapidly growing component of core research activity for all countries. It is encouraged at a policy level because it provides access to a wider range of facilities and resources. International collaboration is particularly important in small to middle range countries because it allows participation in and access to activities from which scientific and technological innovation largely derive (Bourke and Butler, 1995).Over the 20 years period, international collaboration in science and technology has increased. One indicator of this process is the rise in papers co-signed by authors from different countries. The share of world papers with authors in two or more countries has more than tripled between 1981 and 2000, from 5.7% to 18.4%.

Objectives

To analyze the scientific productivity of Pakistan, the following specific objectives are set forth;

- An analysis of the research output of Pakistan , its growth ,rank ,global publications share and impact ;
- A comparison of the overall quantity and quality of Pakistan's research output with selected countries of the world;
- An analysis of Pakistan's research performance broken down by fields;
- An overview of Pakistan's international collaboration.

MATERIAL AND METHODS

The quantity and quality of scientific output of selected 15 countries has been studied in the period 1996-2010. Bibliometric data needed for the study have been obtained from the SCImago Journal and Country Rank (http:/ /www.scimagojr.com) developed by the SciMago Research Group, which provides Scopus data arranged according to country, branch of science and year. The population, GDP and per capita GDP data have been obtained from The Global Competitiveness Report 2011-2012. The R&D expenditure as percentage of GDP has been taken from OCED Factbook 2011-Economic, Environmental and Social Statistics and UNESCO Science Report 2010. The bibliomertic indicators retrieved and calculated in this study are given in various tables. The study initially made a brief review of scientific production in Pakistan in the years between 1996 and 2010. Then the scientific production in Pakistan was compared with that of 14 countries. The countries were: USA, UK, Japan, Germany, France, Canada, China, South Korea, India, Taiwan, Iran, Singapore, Thailand, Malaysia and Pakistan.

The number of publications of each of the selected countries as a percentage of the world publications retrieved from the database was shown. The ratios of scientific output to GDP against each one billion dollars and publications per one million Population in these 15 countries was then calculated and GRED/GDP ratio is also depicted. In the next stage, the relative growth in scientific output of Pakistan with selected countries was compared. Then the major research fields were reviewed and the share of scientific output in Pakistan as compared with the field wise scientific output of the with studied. The quality of research of 15 countries and field wise relative citation impact of Pakistan's scientific was then reviewed. And finally, Pakistan's cooperation with other countries was compared. At the conclusion has been drawn and references have been given conclusion. The definition of the terms of data retrieved from Scimago Website

Documents (Publications)

Number of documents published during the selected year. It is usually called the country's scientific output;

Cites (Citations)

Number of citations of all data received by the documents published during the source year, —i.e. citations in years X, X+1, X+2, X+3... to documents published during year X. Thus, all published documents during the period 1996-2010, are taken into consideration;

Cites per Document (Citation per publication)

Average citations (of all times) per document published during the source year, — i.e. citations in years X, X+1, X+2, X+3... to documents published during year X. Thus, all published documents during the period 1996-2010, are taken into consideration;

H index

The h index is a country's number of articles (h) that have received at least h citations. It quantifies both country scientific productivity and scientific impact and it is also applicable to scientists, journals, etc.

Un-cited Documents (Un-cited Publications)

Number of un-cited documents, i.e. documents that have never been cited;

% International Collaboration

Document ratio whose affiliation includes more than one country address;

% World

Country's relative contribution to world publication output. The present analysis is aimed at comparing the publication growth in Pakistan in relation to the world production (Figure 1). Over the period 1996-2010, there has been a marked increase in the total global output of papers.

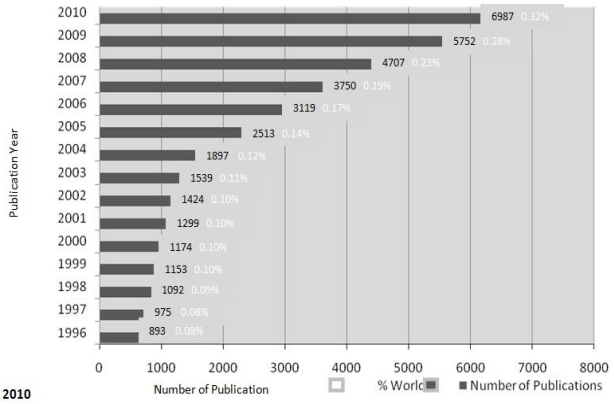

Fig. 1. Growth of publication of Pakistan during the period 1996-2010

In 1996, 1133784 papers were published throughout the world. This number was raised to 2171118 in the year 2010, which shows an increase of 91.49%. A total of 38274 papers were published by Pakistan during the 1996-2010 .The country experienced a slow growth of scientific output for the period 1996-2000 with an average increase of 1057 papers per year. The period 2006-2010 appeared to be the most productive, when there was rapid growth in scientific output with an average increase of 4863 papers per year. However, the absolute volume of publication outputs for Pakistan is very low as compared to other countries, but it has seen a substantial growth in annual output of scientific publications over a period of fifteen years. In 1996, 893 papers were published. This number was raised to 6987 in the year 2010, which shows an increase of 682.42%. The contribution of Pakistani researchers to the world's scientific output was 0.08% in 1996 and Pakistan was at 52nd in the world ranking.

But in the year 2010 a great improvement occurred. In fact this year, Pakistan's total contribution increased to 0.32% and Pakistan ranked as the 43rd country in the production of papers throughout the world. There has been a very rapid growth in the research base for Pakistan, as measured by the volume of research articles. Pakistan's volume output increased more than five-fold between 2001. The research performances of the selected countries were assessed, and comparatively discussed in relation to worldwide reference and the comparison in terms of publications has been made (Table 1). The numbers of research papers published by 15 countries were expressed as the share of the total number of research papers published globally. The selected 15 counties, ranked by the contribution of their scientists to the world's total number of publications from 1996 to 2010 accounted for 64.47% (15031043 papers) of the world's papers (23313389). The top seven countries were the world's seven largest economies. The comparison shows that United States was dominant publishing 22.83% of the world's science. China's growth in publication output has been very strong and now exceeds that of most nations. China has overtaken the UK and Japan in terms of the volume of research papers it publishes and now China is at second position with 7.93% research output. UK ranks number 3 in terms of publications with 6.58%, followed by Japan at 6.28%, then Germany at 5.99%.

Germany thus ranks 5th overall in terms of research productivity measured by publications. France ranked 6th at 4.38%, followed by Canada (3.39%), India (2.29%), South Korea (1.85%), Taiwan (1.32%). Iran, Singapore, Thailand, Malaysia and Pakistan have less than 1% share of publications in the world. Pakistan's share of world papers has increased in recent years but ranked fifteenth in terms of total output of papers within the group of countries selected for comparison (Table 1). Pakistan share's of world papers is small seen against this selected group of nations, all of which have higher GDP and greater Gross Domestic Expenditure on research and development. Pakistan's research outputs have however, become consistently more frequent over the last seven years. Output relative to country size measured by population and gross domestic product (GDP) is also an indicator of the quality of the scientific research output of counties. As a comparison of the ratio of scientific output to GDP in the 15 countries, Taiwan with a registered record of 716.44 against each one billion dollars of GDP stands at the first place. UK and Canada stand at the second and third places with ratio of 682.28 and 502.13 respectively. Pakistan with ratio of 218.83 stands on the fourteen places among 15 countries (Table 1).

To make the research output comparable across countries, publication per population (PPP) is commonly used as measure of the quantity of scientific production of countries instead of the absolute publication number, which referred to hereafter as country's research intensity. The performance in relation to population size of the selected 15 countries is depicted in column 8 of Table 1. In terms research intensity, UK, Canada, and Singapore lead the 15 countries with 24773, 23316, 22780 publications per one million population respectively. Germany, USA, France, Taiwan, and Japan are next after these countries. Large gaps in research intensity are observed. Thailand, India, and Pakistan form the group of the lowest research intensity and have a long way to go to current levels of Malaysia, China, and Iran, which in turn lag behind other developed countries.

Relative to population, the number of publications produced by Pakistan was 207 per one million populations. To a great extent, the gaps in research intensity reflect the different levels of socio- economic development .Intensity correlates strongly with per capita GDP as India and Pakistan have the lowest per capita GDP 1265$ and 1050$ respectively. The picture of world science is further analyzed by looking simultaneously at R&D expenditure and scientific output. In the last column of Table 1, the expenditure in R&D of each selected country is given as a percentage of the GDP. This indicator takes into account the input of a scientific system. A gross positive relationship between the economic potential of a country and its scientific production is displayed. Developing countries are far from reaching the investment levels of scientifically developed countries and efforts must be directed to increase this indicator. The top seven countries by publication shares, which are also the seven largest economies, invest proportionately more in research and development (R&D) in addition to South Korea and Singapore. Pakistan, India, Malaysia, and Thailand have low R&D investment.

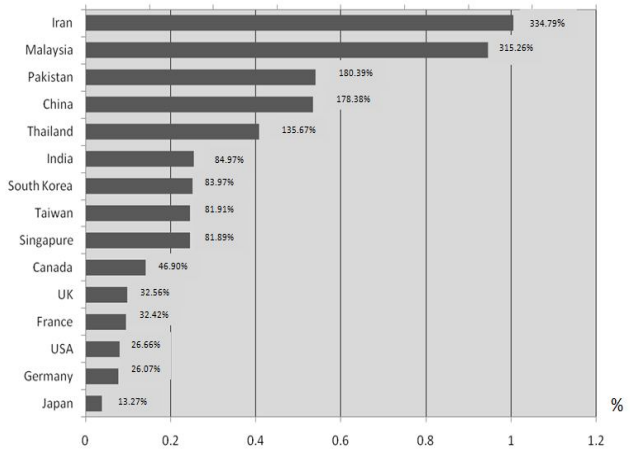

Fig. 2. Relative growth pattern of publications in selected countries from 2001-2005 to 2006-2010

The picture in terms of overall publication output is shown in Table 1. In order to obtain a trend analysis to see increase in publication output over time, the relative growth rate from 2001-2005 to 2006-2010 has been depicted in figure 2.The countries are listed in order of relative growth in their publications. The comparison shows that the greatest growth rates were exhibited by the scientifically emerging countries; Iran, 334.79%, Malaysia, 315.26%; China, 178.38%; and Thailand, 135.67%. The scientifically established countries had lower relative growth in publications: USA,26.66%; UK,32.56%; Japan, 13.27%; Germany, 26.07%; and France,32.42%.Measured in terms of publishing volume, the output of Pakistani research developed favorably over the period of fifteen years from 1996-2010. During this period, the total volume of publications of Pakistan increased 7.82-fold. From 2001-2005 to 2006-2010, the number of Pakistani publications increased by 180.39% and ranked third in terms of relative growth rate of research output among the countries selected for comparison. The statistics shown in Figure 2 indicate overall productivity, but do not reflect which fields of research are experiencing the greatest growth. Here Pakistan's productivity is specifically studied. Pakistan showed growth of 180.39% in publication output from 1996 to 2010.

Significant growth of Pakistani publication activities is found across all scientific fields. The relative growth rate of the publications from 1996-2000 to 2006-2010 for each selected field is shown in the Figure 3. The Multidisciplinary showed very strong growth in terms of output of papers from 2001-2005 to 2006-2010 (1471.43%). The next largest growth occurred in the fields of Mathematics (553.40%), Computer Science (440.97%), Biochemistry (408.07%), Physics (361.27%) Chemical Engineering (345.45%) and Materials Science (312.82%), followed by Agricultural and Biological Sciences (238.88%), Environmental Science (224.71%) which also reflect significant increase.

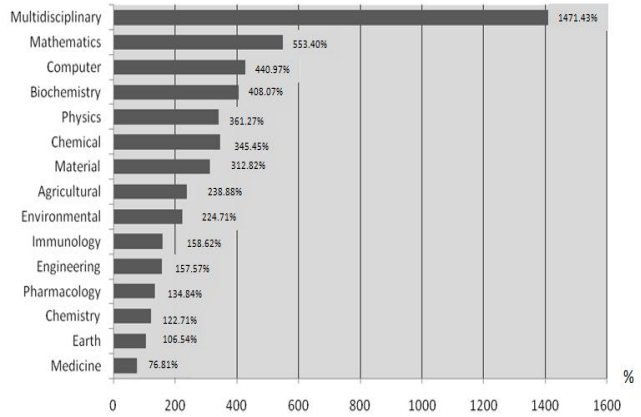

Fig. 3. Growth in Pakistan's Publications by fields from 2001-2005 to 2006-2010

Indicators based on citations received by scientific articles are often used for evaluating the research quality. Pakistan and other countries are compared in terms of the citation impact of their published papers. Table 2 shows the citation analysis of selected countries. In terms of selected countries' percentage shares of citations, the rankings are similar except China. Citations divided by publications gives some measure of the quality of the average paper. In terms citations per paper, the USA still rank first. USA, UK, Canada, Germany, France and Japan have the highest rate of citation (18.88, 16.00, 15.42, 14.64, 13.86, 11.24 citations per publication respectively). The comparisons of average citation rate per paper for Pakistan, China and Malaysia (4.00%, 3.95% and 4.08% respectively) indicate that the quality of Pakistani scientific research is relatively good. However, average citedness of papers published from Pakistan is inferior in comparison with the standards set by the scientifically advanced countries and world average of 10.01%. Looking at the percentage of non-cited articles (%Pnc), it was observed that among developed countries, there was range of 21-28% of published articles that were never cited during the period under review. While in developing countries this range was 30-50%. Higher % pnc usually refer to lower qualities of published articles. Pakistan has more un-cited papers than leading research economies as 43.91% Pakistani publications were not cited at all as against 37.33% of the international literature .Pakistan's number of non- cited publications as a proportion of all publications (43.91%) was lower than just two other countries: Malaysia (48.04%) and China (49.22%). When assessing quality in terms of H index research in these countries still had the higher impact, which means that the publications from these countries are most frequently cited than those from South Korea , India, Taiwan, Singapore and China . Other countries Iran, Malaysia and Pakistan lag far behind in terms of visibility as the H-index of their publications is very low as compared with other countries. The visibility and scientific impact of research in each selected country is compared by means of the relative citation impact, which compares the number of citations received by the publications from each country with number of citations to publications from world on average. In 1996-2010, the relative citation impact for USA, UK, Japan, Germany, France and Canada has been above the world average for this period (Table 2). The one country that comes closest to the relative citation impact value of one is Singapore (0.99). In India, South Korea, Taiwan and Thailand the relative citation impact is more than 0.5 (Table 2). The publications in other countries have so far received less than 0.5 citations as compared to world average. Pakistan's relative citation impact was 0.41 which means that Pakistani publications were cited 59.9 percent less than world average.

It is significant to not only know the quantity of papers a country has produced, but also to examine the number of outputs under each field of research. Table 3 shows Pakistan's contribution to selected main fields of science, as measured by percent share of world papers in each fields. The highest number of outputs in Pakistan is in the field of Agricultural and Biological sciences with 6497 papers, constituting 0.40% of the world's output in the same field. Physics, Mathematics and Medicine accounted for Pakistan's second and third highest percent shares of world papers (0.20%, 0.17% and 0.17% respectively). Table 3 also includes the citation paper per in each of specified fields. Comparing the different fields, Immunology is an area of strength of Pakistan in terms of citation per paper with 11.38 cites per paper. In terms of impact as reflected in average citation per paper, the other maximum impacts were registered by Earth Sciences (7.69), Pharmacology (7.34) and Chemical Engineering (7.19). So far analysis of fifteen countries and Pakistan specifically in terms of publication output as well as citations and in specific fields have been carried. Now to make comparison of impact and influence, the cites per paper relative to world averages by field have been analysed. The relative impacts for Pakistani research output by major fields of science are shown in Figure 4. The number of citations per publication in each field is compare the average world Figure in the corresponding field.

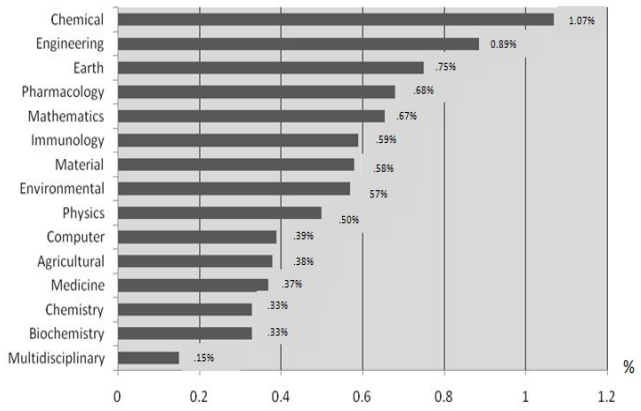

Fig. 4. Relative citation impacts for major fields of science in Pakistan

Table 1. Research output of 15 countries as a % of world output, ratio of scientific output to GDP number publications per one million population and R&D as % of GDP

Country	The proportion of scientific output in world total (%)	Population (million)	GDP (billion$)	GDP per capita	Scientific output	Proportion of scientific output to GDP	Publications per million population	R&D expenditure as % of GDP
USA	22.83	317.6	14657.8	47284	5322590	363.12	16759	2.79
China	7.93	1354.1	5878.3	4382	1848727	314.50	1365	1.70
UK	6.58	61.9	2247.5	36120	1533434	682.28	24773	1.85
Japan	6.28	127.0	5458.9	42820	1464273	268.24	11530	3.33
Germany	5.99	82.1	3315.6	40631	1396126	421.08	17005	2.78
France	4.38	62.6	2582.5	41019	1021041	395.37	16311	2.21
Canada	3.39	33.9	1574.1	46215	790397	502.13	23316	1.92
India	2.29	1214.5	1538.0	1265	533006	346.56	439	0.80
S. Korea	1.85	48.5	1007.1	20591	430438	427.40	8875	3.36
Taiwan	1.32	23.2	430.6	18458	308498	716.44	13297	2.30
Iran	0.52	75.1	357.2	4741	120350	336.93	1603	0.79
Singapore	0.47	4.8	222.7	43117	109346	491.00	22780	2.66
Thailand	0.25	68.1	318.9	4992	59332	186.05	871	0.21
Malaysia	0.24	27.9	238.0	8423	55211	231.98	1979	0.64
Pakistan	0.16	184.8	174.9	1050	38274	218.83	207	0.46

Table 2. Citation Impacts of Publications of selected Countries

Country	Citations	Citation per publication	% of un-cited publications	H- index	Relative impact
USA	100496612	18.88	21.88	1229	1.88
China	7396935	4.00	49.22	316	0.39
UK	24535306	16.00	22.33	750	1.59
Japan	16452234	11.24	26.44	568	1.12
Germany	20437971	14.64	24.23	657	1.46
France	14156535	13.86	25.03	604	1.38
Canada	12187113	15.42	21.91	580	1.54
India	3211864	6.03	35.55	256	0.60
South Korea	3344131	7.77	32.09	287	0.77
Taiwan	2391691	7.75	30.71	229	0.77
Iran	499322	4.15	42.80	106	0.41
Singapore	1092233	9.99	27.75	218	0.99
Thailand	442250	7.45	31.36	145	0.74
Malaysia	218280	3.95	48.04	106	0.39
Pakistan	156030	4.08	43.91	93	0.41

Table 3. Pakistan's share of world publications along with its citation impact in selected fields

Field	Publications	World publications	% of world publications	Citations	Citations Per Publication	H index
Agricultural Sciences	6497	1639731	0.40	26868	4.14	43
Biochemistry	3248	2579771	0.13	21533	6.63	59
Chemical Engineering	1008	904854	0.11	7252	7.19	36
Chemistry	3842	15555663	0.02	17191	4.47	39
Computer Science	997	1054825	0.09	2643	2.65	20
Earth Sciences	582	890848	0.07	4477	7.69	30
Engineering	2721	2809366	0.10	11539	4.24	43
Environmental Science	1207	818690	0.15	8138	6.74	36
Immunology	908	6405624	0.13	10331	11.38	42
Materials Science	1405	1365635	0.10	6120	4.36	28
Mathematics	1549	886440	0.17	6326	4.08	31
Medicine	11102	6405624	0.17	43125	3.88	64
Multidisciplinary	367	236070	0.16	2247	6.12	18
Pharmacology	1006	6241143	0.02	7387	7.34	35
Physics	3495	1719133	0.20	17941	5.13	44

Table 4. Growth in Pakistan's total papers and international collaborative papers

Period	Total papers	Total ICP	Share of ICP
1996-2000	5287	1578	29.85
2001-2005	8672	2220	25.60
2006-2010	24315	8004	32.92
1996-2010	38274	11802	30.84

Table shows that the average citation impact of most of the research in Pakistan remains below world average which is set at 1.00%. Chemical Engineering is at the top with a relative impact of 1.07. The impact of eight fields is in the range of 0.50 to 0.89 as compared to world average. The data shows that Pakistan's research is cited less frequently relative to other countries, and average impact was significantly below world average. International collaboration is an important indicator of the reach and impact of a country's research. Table-4 highlights the level of Pakistan's international collaboration. It shows numbers and percentages of publications with overseas addresses. The collaborations are shown for three time periods: 1996-2000, 2001-2005 and 2006-2010. Out of 38274 papers published in the country during 1996-2010, only 11802 (30.84 %) involved international collaboration. Pakistan's international collaborative share of papers in country's total output increased from 29.85 percent to 32.92percent during 1996-2000 to 2006-2010. In overall, comparing to the growth rate of 359.90 percent of Pakistani research output during 1996-2000 to 2006-2010, the growth rate in international collaborative papers was 407.22 percent during the corresponding period (Table-4).Generally speaking, relatively small science nations have a higher share of

internationally co-authored papers compared to larger nations (Luukonen, Persson, Sivertsen, 1992).

Conclusion

The present study analysed Pakistan's publication activity in terms of global share, share of international collaborative publications and visibility & citation impact for the period 1996-2010. It was found that the Pakistan's total publication output comprised 38274 papers during the 15 years between 1996 and 2010 which was equivalent to 0.32% of the world output during the same period. The contribution of Pakistan to world scientific knowledge is still modest, although there is a rapid growth in scientific research activities in the country during the past 10 years .The growth of scientific publications in the last five years (2006-2010) account for 63.53% of the total publication output .Scientific research in Pakistan in some fields had progressive growth in relation to others as Medicine and Agricultural & Biological Sciences produced 55% of the total research output. This trend has emerged due to the fact that the Pakistan has increased its investment in higher education and scientific research. The plan of action implemented by the Higher Education Commission (HEC) over the past five years has focused on (1) programmes to reverse brain drain, under which the monthly salary of faculty members increased (2) Under its Foreign Faculty Hiring Programme, the HEC has managed to attract 500 highly qualified faculty from abroad to take up positions at universities across the country, including expatriate Pakistani scholars and international experts;(3) The faculty development programme was aggressively pursued by providing merit-base scholarships for training approximately 2400 ph D students per year at universities in developed countries.

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